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Liberalization of agricultural input markets in Bangladesh: process, impact, and lessons

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Abstract

The study takes a historical perspective to trace the path of evolutionary reforms in agricultural input markets of Bangladesh. It estimates the magnitude of the impact of these reforms on rice production, the most important crop in Bangladesh agriculture. It is estimated that the production of rice could have been 20–32% lower than the level of 1992/1993, depending on the rice price that would have prevailed under alternative scenarios. The 20% credit to market reform relates to a real rice price level 19% higher than the actual 1992/1993 prices. The 32% credit to reform relates to the actual 1992/1993 price levels. The lower contribution of reform (20%) to increased production implies a loss to consumers not accounted for in the production benefit of reform, while the higher contribution (32%) of reform entails no loss to consumers. The bottom-line conclusion is that Bangladesh, without the market reforms described in the paper, would have reverted back to the situation of regular food crisis and high rice prices, as was the case historically.

The analysis of the process of reform provides interesting lessons for developing countries. A gradual process based on a well-designed sequencing of various steps of market reform, particularly in the case of fertilizer, was a crucial factor for success. Careful monitoring during the period of transition is another crucial factor that has to be institutionalized in the system. Second generation problems of market reforms, particularly the emergence of an oligopolistic market structure, are possible and warrant a cautionary watch.

1. Introduction

After a long period of chronic foodgrain shortages, Bangladesh has recently achieved a remarkable success in emerging as a marginally self-sufficient producer of rice. It is argued in this paper that the market liberalization measures in agriculture made a significant contribution to this success in rice production. Bangladesh is a country with about 115 million people, 21 million acres of cultivated land, and 12 million farms averaging about 1.8 acres of land per farm in 1990. Because of little scope for extensive farming, most of the increased production has had to come from application of modern agricultural inputs and intensive cultivation. The first serious public effort for introduction of modern inputs in agriculture began with the recommendations of the Agricultural Commission of 1960 (Ahmed, 1978). A public parastatal, the East Pakistan Agricultural Development Corporation (later known as the Bangladesh Agricultural Development Corporation (BADC)), was established in 1963, following a recommendation from the Com-

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mission. This parastatal was given the task of, and resources for, procurement and distribution of agricultural inputs such as fertilizers, seeds, agricultural equipment and pesticides.

The BADC soon developed an elaborate organization and physical capacities all over the country in order to deliver the goods and services to farmers. It had a virtual monopoly over the four agricultural input markets in Bangladesh, even though it had to conform to the pricing and related policies that the government used to formulate from time to time. The purpose of this paper is to examine the process and measure the impact of the recent liberalization of the agricultural input markets that were once vested in a powerful public parastatal. It is hoped that in doing so it will be possible to derive a few lessons relevant to other developing countries.

2. Liberalization of input markets

The step-by-step liberalization of markets for modern inputs in agriculture was carried out partly under pressure from foreign donors and partly on the realization that various direct interventions in these markets were unsustainable and unproductive in a longer-term context.

2.1. Pre-liberalization structure of markets

2.1.1. Fertilizer market

The use of chemical fertilizers was primarily limited to tea estates and to the extent of about 11 400 nutrient tons in 1959–1960. A significant spread of fertilizers to peasants began around the time that BADC was established. The sale of fertilizer by BADC in 1977/1978 was 354 000 nutrient tons (equivalent to 725 000 material tons), consisting of 65% N, 25% P_2O_5, and 8% K_2O (see Appendix, Table A1). This is the picture of progress in the consumption of fertilizer before the process of liberalization was set in motion.

BADC was the sole organization procuring fertilizers from domestic factories and foreign sources. These fertilizers were first shipped to transit warehouses, intermediate warehouses at strategic points, and Thana Sales Centers (TSCs); a thana is an administrative unit consisting of about 80–90 villages. During 1963–1978, there were 67 intermediate warehouses and 423 TSCs. TSCs functioned as both wholesale and retail points in the sense that these sources used to sell fertilizers to private dealers for retailing to farmers as well as directly to farmers. The other category of wholesalers was the Thana Central Cooperative Associations (TCCAs) that sold fertilizers to private dealers and agricultural cooperatives at the village level for retail sales to farmers. The share of cooperatives in the total sale was small, only about 12–17%. Private dealers were appointed for sales to farmers through a licensing procedure and only about three or four dealers used to serve seven to ten villages. The dealers were not supposed to sell outside a defined area. Dealers would procure fertilizers from specified TSCs and sell to farmers at prices fixed by the government. The fixed price included a commission based on the distance from the TSC to the operation center. Dealers were required to maintain registers, which were subject to occasional inspection by BADC officers. Excluding the commission prices of fertilizers were supposed to be uniform throughout the country. The system suffered from numerous problems arising from excessive bureaucratic controls.

2.1.2. Irrigation equipment

BADC started the low-lift pump irrigation (lifting water from surface sources to adjoining fields) using diesel engines and distribution pipes, mainly for reclamation of Haor areas of Sylhet and Mymensingh districts (Haor is a lake-like depression in low-lying marshy stretches of land). Most of these engines were of 2 cusec capacity. BADC used to own, maintain, and operate these pumping sets to supply water to groups of farms on the basis of a flat charge per acre. At the beginning, the charges covered only about 60% of the operating cost. This experiment in Haor areas led to a rapid expansion of the scheme throughout the country along riverbanks, large ponds, and lakes. Operation of a large fleet of pumping sets became an unwieldy task and expensive too. Therefore, by the end of the 1960s, some reforms were introduced. Farmers were required to orga-

nize into irrigation groups, supply all diesel fuel costs, and pay a share of the maintenance cost at flat rates per acre of irrigated land. Farm groups were responsible for water management, diesel fuel, and collection of charges. By the mid-1970s a rental system was introduced, whereby BADC's responsibility was only to supply an operationally good pumping set on a rental basis and farm groups had to bear all costs, including wages of pump operators.

Tube-well irrigation is the other mode of small-scale irrigation development in Bangladesh. This is suitable for areas where surface water is not available and underground water is the next best source of water supply. The first program on tube-well irrigation was initiated by the Bangladesh Water Development Board in the early 1960s with 90 tube-wells of 2–3 cusec capacity engines in northern Bangladesh. For many years, the project could not successfully attract farmers, even with 100% subsidy. BADC began a deep tube-well program (2 cusec capacity) around the time when its low-lift pump program reached saturation. In the meantime, Comilla Academy for Rural Development was successfully experimenting with shallow tube-wells of 0.25–1 cusec capacity through cooperative societies. These shallow tube-wells were found to be much cheaper than BADC tube-wells. The Comilla Academy also implemented a program of training for development of private sector tube-well installation capacity in the country. BADC started a modest tube-well irrigation program based on 2 cusec wells as early as 1970. Initially, BADC operated these tube-wells on the same principles for low-lift pumps. Around 1978 BADC was asked to install tube-wells for farmers on payment of the subsidized cost (20–30% subsidy). Except for these publicly initiated programs of tube-well irrigation, there was hardly any private initiative in the development of modern irrigation until the mid-1970s.

Irrigation equipment (engines, pumps, etc.) had all along a small private market for use in nonagricultural purposes. BADC's equipment was mostly imported under foreign aid. Domestic capacity for production of diesel engines and pumps was small. Therefore, liberalization of import trade became the key element of market liberalization in agricultural equipment. Before the mid-1980s, the following types of import restrictions were in effect.

(a) Private import of diesel engines for irrigation was not allowed except for makes and models approved by a Standardization Committee in the Ministry of Agriculture (MOA) and with special permission from MOA.
(b) Private import of pumps for irrigation was not allowed except with MOA permission, with foreign exchange through a donor-funded project, and with no objection from the Ministry of Industries.

2.1.3. Cultivation equipment

As with other modern inputs in agriculture, BADC started a mechanized cultivation scheme based on tractors from the inception of BADC. However, experiments with tractors became unsuccessful rather quickly. Thereafter, the Pak-Japan (later known as Bangladesh-Japan) Cooperative Scheme on Agricultural Machineries successfully introduced power tillers for plowing of land by farmers. However, no special public agency was created, as had been done for other inputs, for marketing and distribution of power tillers. Private importers and distributors have been performing this function, since some demand for power tillers has been felt in the market. Medium-to-large farms purchase power tillers for renting to neighbors and for meeting their own draft requirements. Thus the domestic market was free but the import market was constrained. Before the mid-1980s, private import of power tillers was not allowed except for makes and models approved by a standardization committee in the MOA (Gisselquist, 1992).

2.1.4. Pesticides

BADC was given the task of procurement of plant protection materials, and the Agricultural Extension Department was supposed to conduct operations for crop protection. Because of numerous complexities in the storage and handling of poisonous materials and in dispensing these materials to farmers, and because of the recognition that a bureaucratic agency can hardly take

timely measures against pests, the ground measures of crop protection, including procurement and distribution of pesticides were privatized at the end of the 1960s. Private importers began importing and distributing pesticides through private dealers and general retailers of consumer goods. However, import of pesticides by private dealers was allowed only for approved brands and approved dealers with permission from MOA. This approval process might have implied hidden costs for traders, and import only by brand names was potentially oligopolistic. A 1991 study by Canada's Agricultural Sector Team in Bangladesh found pesticide prices as much as double the prices in Pakistan despite the absence of tariffs (Canadian Agency for International Development, 1991).

2.1.5. Seeds

The traditional seed markets in Bangladesh involve farmers producing seed for their own use and for sale to markets. Those who need seeds buy from the market. It is not uncommon for some farmers to specialize in the production of seeds. These traditional markets have been the channel of distribution not only among farmers within the country but also between adjoining farmers of Bangladesh and India. The other

Table 1
Step-by-step liberalization of agricultural input markets, Bangladesh

Actions	Time span	Remarks
(A) Fertilizer market		
1. BADC withdrew from retail and wholesale markets at Thana levels, the primary distribution points	1978–1983	This was done at Chittagong Division first. Vigorous response from traders
2. Licensing requirement was abolished and restriction on movement removed (except 5 mile border zones with India)	1982–1983	
3. Deregulation of fertilizer price	1982–1984	Real competition started
4. Allowing private traders direct purchase from factory gates and port points	1989	Vigorous response from traders
5. Free import from world market	1992	Good response, but fear of oligopoly persists
(B) Irrigation devices		
1. BADC sold all its low-lift pumps to private parties backed by special credit arrangement for purchases	1980–1982	Good response from farmers
2. BADC sold all its tube-wells for irrigation to farmers and cooperatives; sale supported by special credit arrangement for purchasers	1983–1985	Good response from farmers
3. Restriction on import of engines and pumps withdrawn	1988	Drastic fall in prices of engines
4. Standardization restrictions limiting makes and models removed	1988	Drastic fall in prices of engines
(C) Power tillers, pesticides, and seeds		
1. Restriction on power tiller import and standardization requirement removed	1989	Modest response
2. Restriction on import by brand names liberalized for pesticides	±1989	Modest response
3. Except rice and wheat, all seed import liberalized	1990	Modest response

Source: Computed from information in Mudahar (1984), Sidhu (1992), Gisselquist (1992), Asian Development Bank, (1990), Bangladesh Establishment Division (1992), and personal contact of the author, July 1993.

channel that provides improved varieties developed in research stations is the public system. BADC has been operating about 19 seed multiplication farms for production and distribution of such improved seeds of various crops. The government has developed a seed certification mechanism for ensuring quality. But complaints that publicly produced seeds are frequently of poor quality and not available in time are quite common.

BADC has imported seeds in the past in order to introduce high yielding varieties (HYVs) of crops. Examples of imports of Dutch potatoes and Mexican wheat in order to increase production of these two crops are well-known. It is believed that the liberalization of seed markets aimed at promoting free and competitive international trade in seed would be a potent mechanism of technological progress in the agriculture of Bangladesh.

2.2. Reforms in input markets

The chronology of reforms in the agricultural input markets is summarized in Table 1. Liberalization of the fertilizer and the irrigation equipment markets was the dominant feature of the reform that produced a substantial impact on production. In the case of fertilizer, the response of private trade was very vigorous. It was estimated that 8000 wholesalers and 50 000 retailers operated competitively in the fertilizer market by 1988 (Infanger et al., 1988). The share of private trade went up quite fast; the share was 75% in 1989 and about 100% in 1992. Nevertheless, some doubts still persist that the trade at the import level may ultimately turn into an oligopolistic structure because of economies of scale in importation and differential access of traders to capital markets. Throughout the entire process of reform, a carefully designed mechanism of monitoring was working to identify emerging problems and solve them in time.

Perhaps the most significant effect of reforms was realized in the case of irrigation equipment. By early 1989, the cost of a shallow tube-well complete with sinking, pipe, pump, and engine, to irrigate 4–5 ha of land, had fallen to below the 20 000 ($600) which is about 60% of the subsidized price for such equipment through BADC. As a result, during the period 1988–1990, irrigated area expanded at a rate roughly twice as quickly as had been achieved in 1978–1986. The practice of using power tillers for cultivation is still very thin in Bangladesh. The price of a power tiller had decreased to $1500 in 1989 from $2500 only a few months before the liberalization of import (Gisselquist, 1992). The use of power tillers is spreading faster than before due to the removal of import restrictions; liberalization of markets for seeds and pesticides has only a modest implication for impact in the short run. But in the long run their impact, particularly that of seed, is likely to be perceptably large.

3. Impact of liberalization

The impact of liberalization can be assumed to consist of two elements: (a) direct impact on agricultural production due to changes in the level of input use; (b) indirect impact on the production of both agricultural and nonagricultural products arising from reallocation of budgetary savings achieved through reduction or elimination of input subsidies. These savings are likely to impact the price of foreign exchange, which in turn may influence production. It is the direct impact that is traced and measured in this paper. Measurement of the indirect impact warrants an economy-wide modeling that is not attempted here. Nevertheless, some assessment of the fiscal impact or the magnitude of a subsidy that was eliminated from the budget is provided here.

Detailed calculations indicate that the budgetary subsidy on fertilizers was of the order of TK 1286 million ($83 million) in 1979/1980, TK 1426 million ($57 million) in 1983/1984, TK 1273 million ($40 million) in 1988/1989, and only about TK 25 million ($0.6 million) in 1992/1993 (Ahmed, 1987; Renfroe, 1991; and personal contacts in the Bangladesh Ministry of Agriculture, July 1993). The small subsidy in 1993 is meant for correction of minor and trace-element deficiencies in certain soils. The 1983/1984 figure was

equivalent to about 14% of the total public development expenditure on agriculture and rural development, and the 1979/1980 figure was equivalent to 28% of such expenditure (International Food Policy Research Institute, 1985). Budgetary savings arising from liberalization of the fertilizer market are quite significant. A comparable estimate of the subsidy for irrigation is not available. However, the budgetary subsidy on the low-lift and tube-well irrigation program of BADC was estimated to be TK 1035 million ($66.7 million) in 1979/1980 and TK 830 million ($33 million) in 1983/1984 (Rashid, 1986). By 1986, almost the entire subsidy on low-lift and tube-well irrigation of BADC had been eliminated.

3.1. Model for measuring direct impact on rice production

Although the impact of policy reform on aggregate production of rice is the objective, the approach to measurement must be rooted in the farm level behavior. Consider a typical farm with a production function

$$V = F(X_1 \ldots X_m;\ Z_1 \ldots Z_n) \tag{1}$$

where V is output, X represents variable inputs, and Z represents fixed inputs and other shifter variables of the function. The farm is seeking maximization of profit

$$\Pi = PF(X_1 \ldots X_m;\ Z_1 \ldots Z_n) - \sum_j^m q_j X_j \tag{2}$$

where P is the unit price of output, q_j is the unit price of the jth variable input. The fixed costs are conveniently ignored. The profit maximizing level of input use is given by

$$\frac{\partial F}{\partial X_j} = q_j / P \tag{3}$$

Eq. (3) can be solved for optimal quantities of variable inputs denoted as x_j^* as a function of prices and Z

$$X_j^* = F_j(p, q, z) \tag{4}$$

By substitution of Eq. (4) into Eq. (2), the restricted profit function becomes

$$\Pi = G(P, q_1 \ldots q_m;\ z_1 \ldots z_n) \tag{5}$$

This general function gives maximized values for the optimal sets of $(q_1 \ldots q_m)$ so that

$$\Pi = G^*(P, q_1 \ldots q_m;\ z_1 \ldots z_n) \tag{6}$$

It is possible to derive output supply and input demand functions from Eq. (6) via Shepard's (1970) lemma.

The output supply function

$$V^* = \Pi(P, q, z) \tag{7}$$

and input demand function:

$$X_j^* = F_j(P, q, z) \tag{8}$$

The function is negative in input prices.

Note that p and q can be expressed in relative terms collapsing the two vectors into one of relative prices of output and input.

The values of v^* and x_j^* relate to a typical farm. If there are n number of such farms (measured in efficiency units) in an economy, the aggregate values can be obtained by multiplication of v^* and x_j^* by n

$$\text{aggregate } V_a^* = nv^* \tag{9}$$

$$\text{aggregate } X_a = nX_j \tag{10}$$

At the household level, it has been assumed that farms are price takers. In aggregate levels, the prices of outputs and inputs may have to be appropriately treated in the context of the problem at hand.

Grounded on the microeconomics of production as outlined above, an empirical aggregate model is developed that simultaneously determines input use and crop production. The model is specified as follows

$$FC_t = f(\mathrm{PFR}_t/PR_t,\ AG_t,\ \mathrm{NAR}_t,\ \mathrm{CDS}_t/P_t,\ D) \tag{11}$$

$$(\mathrm{PFR}_t/PR_t) = f(\mathrm{PFD}_t/PR_t,\ \mathrm{HYV},\ \mathrm{PFM}_t/PR_t,\ D) \tag{12}$$

$$AG_t = f(DP_t/PR_t,\ EG_t/P_t,\ CDL_t/P_t,\ D) \tag{13}$$

$$\mathrm{DAR}_t = f\{AG_t,\ PR_t/PO_t,\ D\} \tag{14}$$

$$QR_t = f(FC_t,\ AG_t,\ \mathrm{DAR}_t,\ D) \tag{15}$$

where FC_t is consumption of fertilizers (urea, triple superphosphate, and murate of potash) in year t (measured in thousands of tons); PFR_t, PFD_t, and PFM_t are, respectively, retail, domestic factory gate, and border prices of fertilizer in year t (measured in TK ton^{-1}; prices are weighted average of three types of fertilizers); PR_t is the wholesale price of rice in year t (TK ton^{-1}); AG_t is the total irrigated area in year t (thousands of acres); NAR_t is the nonirrigated crop area in year t (acres in thousands); CDS_t is the short-term crop loan advanced to farmers from banking institutions and public agencies in year t (10 million TK); P is the general price index; PD_t is the price of diesel fuel in year t (TK ton^{-1}); D is the dummy variable that takes a value of 0 for years from 1975 to 1984 and 1 for years from 1985 to 1993; EG_t is the public expenditure on water control and irrigation development in year t (10 million TK); CDL_t is the long-term loan to farmers from banks and public agencies in year t (10 million TK); DAR_t is the dryland rice in year t (acres in thousands); HYV is the area under high-yielding varieties of rice (in thousand acres); PO_t is the price of mustard oil seeds (TK ton^{-1}) as proxy for crop prices other than rice.

Rice production is selected as the proxy for total crop production. Rice contributes about 73% of GDP in the crop sector; 85% of fertilizers and 95% of irrigated areas in Bangladesh are used for rice (Chowdhury, 1993).

The following hypotheses are considered very plausible in the light of evidence from previous studies (Ahmed, 1978; Stone, 1987; Hossain, 1988):

(a) change in fertilizer consumption
  - due to change in real price of fertilizer: negative
  - due to change in irrigated area: positive
  - due to change in nonirrigated area: zero or positive
  - due to change in volume of crop loan: positive

(b) change in irrigated area
  - due to change in real price of diesel fuel which is critical for tube-wells and low-lift pumps: negative
  - public expenditure on water control and irrigation: positive or zero
  - long-term credit to agriculture: positive

(c) change in retail price of fertilizer
  - due to change in domestic factory-gate price: positive
  - due to change in border price (world price and exchange rate): positive
  - due to change in HYV: positive

(d) change in dryland rice area
  - due to irrigation expansion: negative or zero
  - due to increase in relative price of rice, positive

(e) change in rice production
  - due to change in fertilizer use: positive
  - due to change in irrigated area: positive
  - due to change in dryland rice area: positive

Most of the hypotheses may appear to be quite obvious and sensible except the effects of (a) nonirrigated area on fertilizer, (b) public expenditure for water control and irrigation on irrigated area, and (c) long-term credit to agriculture on irrigated area. In Bangladesh, fertilizer use in nonirrigated crops is generally very spotty due to various risks associated with such land and underdeveloped technology for nonirrigated crops. In the case of public expenditure for water control and irrigation, the effect is hypothesized to be either zero or positive mainly for three reasons. First, the bulk of this expenditure is meant for flood control that does not influence irrigation. Second, the part of this expenditure that goes for irrigation is meant for large (greater than 2 cusec capacity) tube-wells and surface irrigation structures. Both these types are known to be extremely ineffective in getting farmers' participation. Third, public expenditure on irrigation and actual irrigated areas perhaps bears a lagged relationship that could not be realistically specified with the information available. Long-term credit to agriculture in Bangladesh is largely meant for modern farm equipment. Tube-well and low-lift pump equipment for irrigation and

power tillers for cultivation constitute the main opportunities for such investments in the country's agriculture.

The most important and relevant hypothesis in the context of the focus of this analysis is the effect of the dummy variable, D. The dummy is designed to capture the complex effects of various changes induced by the liberalization measures on the levels of use of inputs and production. There is no a priori presumption that the effect of the dummy would be positive or negative, except that the coefficient of the dummy in Eq. (15) is expected to be not significantly different from zero. This is so because the impact on production occurs through the impact on the levels of use of inputs, particularly in the case of fertilizers, and because the irrigation input is measured in terms of irrigated area that already is inclusive of any effect of change in irrigation techniques. The productivities of these inputs are not expected to be influenced by the liberalization measures. Shifts in productivity are more a function of technological change that do not pertain directly to the liberalization measures, at least within the context of time to which this analysis is limited. However, a brief reflection on these complex changes that are likely to be induced by policy liberalization measures and expected to be captured by the dummy is in order.

In the case of fertilizers, the complex changes induced by liberalization measures that are not explicitly included as explanatory variables concern real costs of fertilizers to producers and availability of the input at the right time and place because of a greatly enhanced competitive market after privatization, deregulation of market, and decontrol of prices. The price of fertilizer that is included as an explanatory variable does not include various discounts that the dealers are known to have been providing to purchasers of fertilizers in order to reap quick profits by increasing business turnovers. Similarly, fertilizer dealers are known to have resorted to sales on informal credit to their subordinate retailers and farmers (World Bank, 1992; Chowdhury, 1993). Moreover, increasing the access of fertilizer dealers to factory-gate deliveries, instead of previously practiced controlled delivery from BADC stores, must have enhanced the speed and volume of overall supply in the market. In the case of irrigation, it was mentioned in Section 2 that the price and supply of low-lift pump and tube-well engines were suddenly changed (price decreased and supply increased) by market liberalization, including withdrawal of import restrictions. These price and supply data are not systematically recorded anywhere for their treatment as explanatory variables in the model; hence the dummy variable is designed to pick up the effects.

Besides the foregoing hypothesis, three other considerations bearing upon the specification of the model need a brief explanation. The first consideration concerns the selection of 1984/1985 as the splitting point between the post- and pre-liberalization periods. Although the process of liberalization had proceeded in a gradual fashion, certain major and most relevant ones occurred around 1984. The deregulation and privatization of the fertilizer market, particularly the decontrol of prices, were effectively completed by 1984. The access of dealers to factory gate supply was initiated around that time. Similarly, the deregulation and privatization of low-lift and tube-well irrigation formally took effect in the years from 1981 through 1986, although the trade restriction on import of irrigation equipment took effect a few years later. The second consideration concerns the fact that HYVs of rice do not appear in any equation. Analysis of HYV area and irrigation indicated that the correlation between the changes in HYV area and changes in irrigated area was very high (0.91). For this high degree of multicollinearity between the two variables, the effect of irrigation has to be viewed as inclusive of the effect of HYVs. Although fertilizer and irrigation are also positively correlated, this correlation is not as strong as between irrigation and HYVs. The third consideration regarding the specification is that the variable NAG and a few others have not been endogenized in the model. The type of information (e.g. relative profitability in irrigated and nonirrigated crops in a time-series framework) were not available to endogenize NAG. Moreover, given the known high profitability of irrigated rice crops, NAG remains primarily

a function of weather conditions (rainfall, drought, etc.). CDS, *PD*, and CDL were not endogenized partly because they are hardly influenced directly by the input market liberalization, and partly because such an extension of the model would ultimately devolve into a general equilibrium framework that is beyond the scope of the study.

The last consideration relates to the labor market. No variables on supply and demand for labor are included in the model. Rural labor markets are generally not as distorted as urban labor markets because the distortive labor laws are inoperative in rural areas. Therefore, it is the effect of reforms in fertilizer and agricultural equipment on labor utilization in agricultural production that remains to be a valid concern. Moreover, annual data on labor services (as opposed to stock of labor) used in production are not available to incorporate such variables as explanatory factors in the equations. In a generally labor surplus economy, such as Bangladesh, and with a relatively undistorted rural labor market, the exclusion of labor from the model is not likely to influence the measurement of the contribution of input market reform to production. In terms of labor's contribution to production in Eq. (15), the implication is that such a contribution is mixed with the contribution of land and other inputs.

With this brief discussion on hypotheses and model specification, results of estimation are now presented.

4. Estimation and results

The system of Eqs. (11)–(15) is estimated using Zellner's Seemingly Unrelated Regression (SUR) model. This model is efficient in situations where the equations are closely interrelated with the possibility of the error term of one equation being correlated with the error term of another. Before using the SUR model, the equations were estimated using the simple OLS model. The adjusted R^2 values were generally quite high.

The results prove that most of the hypotheses concerning input use are true. The effects of the dummy variable designed to capture the influence of liberalization on fertilizer consumption and irrigated area demonstrate that these measures have had a positive and substantial impact. This positive impact on irrigation and fertilizer in turn resulted in a positive impact on rice production. These findings belie the arguments by vested-interest groups that liberalization of agricultural input markets have been counterproductive in Bangladesh.

Fertilizer consumption increased at an annual rate of 9.0% in the preliberalization period (1975–1984) compared with the growth rate of 10.04% $year^{-1}$ during the postliberalization period. However, the growth in the former period occurred from a low base of only 450 thousand tons (see Appendix, Table A2). The consumption function of fertilizer shows that fertilizer price relative to rice price, irrigated area, short-term crop loans, and the complex sets of forces represented by the dummy are the significant explanatory factors for use of fertilizer. Of these factors, the real price of fertilizer at the retail level increased annually at about 4% in the first period but decreased annually at about 3% in the second period. This is primarily because of a fast increase in nominal fertilizer prices during the later part of the first period. Even though the government attempted to control fertilizer prices during the preliberalization period, rapidly growing factory-gate prices spurred by increased production costs, and rising world prices contributed to these increases in fertilizer prices during the preliberalization period. Once the rise in fertilizer prices reached a peak by 1984, further growth was slowed by slow growth in factory-gate as well as world prices in the second period (see Appendix, Table A2). A slow growth in rice prices in the second period was of course not low enough to match the very slow rate of increase in the nominal price of fertilizer, thus resulting in a decline in the rate of change in the real price of fertilizer and a positive price effect on fertilizer consumption in this period.

Fertilizer prices at the retail level are found to be primarily dependent on factory-gate prices and world prices as hypothesized, the effect of the former being about four times the effect of

the latter. However, the difference between retail and factory-gate prices peaked just around the time of liberalization but substantially narrowed in recent years after the liberalization measures had some time to increase competition and thus reduce the marketing margin of traders.

The effect of forces underlying the dummy variable has a significantly positive impact on the consumption of fertilizers. The value of the dummy is equal to about 55% of the average consumption of fertilizer in 1984 and 1985. The other two significant factors, short-term credit (CDS) and irrigated area (AG), had opposing trends between the two periods. Irrigated area increased at an annual rate of 5.4% in the first period and 20.49% in the second period. But short-term credit increased at an annual rate of 28.83% in the first period and declined at a rate of 7% in the second period.

The higher rate of increase in irrigated area in the second period is largely attributed to liberalization policies underlying the dummy variable — as will be seen from the results presented in Table 2. Besides the dummy variable, the other two significant factors are diesel price (PD) and long-term credit to agriculture (CDL). The negative relation between diesel price and irrigated area, in conjunction with a faster increase in diesel price in the first period compared with a slower increase in the second period, implies a positive impact of diesel price on irrigated area in the second period compared with the first. But long-term credit bears a positive relation to irrigated area. The faster increase in long-term credit in the first period compared with the rate in the second period implies that this factor produced a net depressing effect on the expansion of irrigated area in the second period compared to the first. The effect of the forces underlying the dummy variable is reflected in the coefficient of the dummy. This value is about 130% of the average irrigated area in 1984 and 1985 and about 33% of the irrigated area in 1992.

The statistically insignificant coefficient of the dummy variable in Eq. (15) indicates, as hypothesized, that the effect of input market liberalization on the production of rice was realized primarily through the changes in the levels of input use rather than any technical changes outside the markets for fertilizer and irrigation inputs. Such technical changes (e.g. replacement of diesel by electric engines, use of new rice seeds imported from India, change in composition of fertilizers) might have occurred on a small scale but was not significantly large to create a perceptible impact.

The net effect of the input market reforms, defined as the difference between the scenarios with and without reform, is shown in Table 3. This is estimated by solving the models for

Table 2
SUR estimates of fertilizer consumption, fertilizer price, irrigated area, and rice production

Functions	Coefficient	t-statistics	$\bar{R}^2$
(1) Fertilizer consumption (FC)			
Intercept	875.62	3.98	0.94
Fertilizer price (PFR/PR)	−644.31	−2.13	
Irrigated area (AG)	0.20	8.72	
Nonirrigated area (NAG)	0.04	1.03	
Short-term credit (CDS/P) (crop loan)	9.82	1.90	
Dummy (D)	626.62	4.62	
(2) Fertilizer price (PFR/PR)			
Intercept	0.069	0.837	0.59
Factory-gate price (PFD/PR)	0.807	2.592	
Border price (PFM/PR)	0.227	1.569	
HYV area	0.034	1.035	
Dummy (D)	−0.031	−0.865	
(3) Irrigated area (AG)			
Intercept	2409.0	1.29	0.65
Diesel price (PD/PR)	−262.93	−1.78	
Public expenditure (EG/P)	388.43	0.81	
Long-term credit (CDL/P)	65.00	1.81	
Dummy (D)	2480.94	4.12	
(4) Dryland rice area (DAR)			
Intercept	18500.0	2.56	0.76
Irrigated area (AG)	0.02	0.87	
Rice price (PR/PO)	412.1	3.72	
Dummy (D)	120.5	0.57	
(5) Rice production (QR)			
Intercept	1909.07	1.86	0.96
Fertilizer consumption (FC)	3.06	5.97	
Irrigated area (AG)	0.44	3.10	
Dryland rice area (DAR)	0.31	8.12	
Dummy (D)	277.33	0.83	

R^2 relates to separate OLS estimation.

Table 3
Estimated production of rice and use of inputs, 1992/1993

Reform status	Production (1000 tons)	Use of fertilizer (1000 tons)	Irrigated area (1000 acres)
(a) With market reform	18388	2,594	6,208
(b) Without market reform (version 1)	13938	1,526	3,728
(c) Without market reform (version 2)	15332	1,685	3,833
Net effect of reform [a] *(%)*			
P			
Version 1 (a − b)	32	70	67
Version 2 (a − c)	20	54	62

[a] Net effect is calculated by deducting the without-reform level from the with-reform level and dividing the difference by the without-reform quantity. The result is expressed as a percentage.

1992/1993. The solution is conducted first by estimating the irrigated area (AG) from Eq. (13) with 1992/1993 actual values of exogenous variables and using the value of 0 for D in the case of the without-reform scenario and the value of 1 for D in the case of the with-reform scenario. These solutions are then plugged into Eq. (11) for estimating the levels of FC under two scenarios. Other exogenous variables in Eq. (11) are assumed to prevail at the actual levels of 1992/1993. These solutions for AG and FC are then plugged into Eq. (15) to arrive at production of rice under the two scenarios. In Table 3, there are, however, two versions of the without-reform scenarios so that we have three scenarios in all: (a) with reform, (b) without reform version 1, and (c) without reform version 2. It was clear from the preliminary estimate of the 'without reform' scenario that the growth in rice production would lag substantially behind the demand so that Bangladesh would be reverting back to the status of a consistent importer. Under this condition, the acutal 1992/1993 level of rice price that was assumed in (b) would no longer be valid. Therefore, the scenario (c) was estimated, using the import parity price rather than the 1992/1993 actual price. The import parity rice price in 1992/1993 was about 19% higher than the actual price; the actual price was slightly above the export parity price.

The counterfactual results in Table 3 indicate that the reforms in the fertilizer and irrigation markets of Bangladesh can be reasonably credited with the remarkable success in rice production. The reform measures contributed to about 20–32% of the increase in production. This increase is primarily attributed to the impact of reform on fertilizer consumption and private sector irrigation development.

The range of increases in production and input use shown in Table 3 reflect the differences that prices of rice under the scenarios of with and without reform would entail. Version 1 of the without-reform scenario imposes no change on consumers' welfare by assuming a price level for rice which prevailed in 1992/1993. Without reform, as the production slows down or stagnates, the rice price would rise imposing a welfare loss to consumers, although inducing some gain in production and to producers. This is shown in version 2 of the without-reform scenario. The way contribution of reform has been defined, limiting only to production and producers, version 1 credits reform policies with 32% of the increase in rice production. However, with version 2 that assumes a welfare loss to consumers via the increase in rice prices, the share of credit to reform policies drops from 32% to 20%. The basic conclusion that can be drawn from this exercise is that Bangladesh would have remained immersed in foodgrain shortages and higher food prices had there been no changes in the fiscally unsustainable public interventions in agricultural input markets.

5. Lessons and conclusions

This paper takes a historical perspective to trace the path of evolution of the contemporary reforms in agricultural input markets. In the context of Bangladesh, no such study is known to have been done evaluating the contribution of reform and deriving lessons therefrom. However, Osmani and Quasem (1990) conducted a study at the beginning of market reform, when the debate

on fertilizer subsidy peaked in Bangladesh. This study argued in favor of fertilizer subsidy as a strategic factor for foodgrain self-sufficiency and asserted that market reform meant to create a capitalistic mode of production would make the goal of foodgrain self-sufficiency recede further. Of course, the literature on macro-economic reform globally, focusing on the general structures of incentives that such reforms imply, is quite rich (Schiff and Valdes, 1992; McKinnon, 1993). Studies on sectoral policy reforms on Africa are similarly quite numerous but not always grounded on systematic case studies (World Bank, 1994). This paper is expected to contribute to the understanding of the process and the impact of sectoral policy reforms in one of the poorest countries of the developing world.

Liberalization of the agricultural input markets of Bangladesh can be credited with the remarkable success in rice production in recent years. It is estimated that the production of rice could have been 20–32% lower than the level of 1992/1993, depending on the rice price that would have prevailed under alternative scenarios. The 20% credit to market reform relates to a real rice price level 19% higher than the actual 1992/1993 prices. The 32% credit to reform relates to the actual 1992/1993 price levels. The lower contribution of reform (20%) to increased production implies a loss to consumers not accounted in the production benefit of reform while the higher contribution (32%) of reform entails no loss to consumers. The bottom-line conclusion is that Bangladesh, without the market reforms described in the paper, would have reverted back to the situation of regular food crisis and high rice prices, as was the case historically.

Many developing countries are currently attempting to liberalize their input markets. Therefore, the lessons from Bangladesh can have some usefulness internationally, except, perhaps, former communist countries.

(1) Modern inputs such as fertilizer, power-driven equipment, HYV seeds, and pesticides are technologies generally unfamiliar to farmers at the introductory stage. Initially, markets do not exist, and public initiative begins with market creation. This initial period of "market failure" is quite different from the period when modern inputs have become reasonably well known to farmers and market size has become reasonably adequate for a viable competitive market. The Bangladesh case demonstrates that such a stage was possibly attained by the end of the 1960s in the case of fertilizers and pesticides and by the end of the 1970s in the cases of agricultural equipment and seeds. In that sense, the liberalization of input markets could have productively begun much earlier than it actually happened.

(2) The evolution of the forces that drove public marketing out of circulation in Bangladesh provides an interesting lesson. Donor conditionality was definitely a powerful factor. But that alone does not explain the changes. There were a number of other compelling factors of domestic origin. Budgetary burden is one of them. The rapid changes in removal of subsidies, privatization, and liberalization of import restrictions that have happened in recent years bear testimony to the political will of a government to change its mode of agricultural development.

(3) Liberalization of markets at one shot — the so-called shock therapy approach, and liberalization in phases (the so-called gradual approach) — have been much debated in the literature as well as in policy circles. If phasing is unavoidable, the question of what sequence should be followed becomes quite relevant. The Bangladesh experience provides a lesson on this issue. The successful one-shot approach has rarely been a real-world example, and sequencing of reform measures generally plays a strategic role in liberalization.

One order of sequencing is the introduction of competitive trading in various layers of the marketing channel from grass-root retailing to wholesaling and thence to the apex involving external trade, in a stage-by-stage fashion. There is merit in this approach. Generally, the public-sector efficiency improves as it withdraws from retail to wholesale and thence to the apex; it loses efficiency as it extends from the apex level to the wholesale and thence to the retail links of the marketing channel. Contrary to this experience,

the degree of competition in private trade generally diminishes as one moves from retail to wholesale to the apex. The relative strength and weakness of the public and private sectors in marketing imply that the best strategy of sequencing is the privatization of the retail market first and then a gradual move up to the apex level. This is the sequence followed in the input markets of Bangladesh.

(4) Another order of sequencing would be a gradual geographical coverage of markets by reform measures, as was done in the case of privatization and price decontrol of fertilizers in Bangladesh. This is generally done to avoid a risky failure at the beginning. A country-wide privatization and liberalization may occasionally create turmoil and unforeseen side effects that a weak administration may not be able to handle. When no side effects are observed, a quick extension to all regions can be made. This gradual geographical coverage is an option for consideration only when the risk of failure is very high and a vested interest is perceived to be working to demonstrate a failure. When a gradual regional coverage is adopted, it is desirable to begin with the region that has a relatively strong basis in terms of demand for the input in question.

(5) Complementary support to the principal program of liberalization is almost always a critical factor for success. Monitoring of changes in supply, demand, prices, and emerging situations is essential. Without a well-thought-out support plan, the liberalization process has often been found to falter. In the case of fertilizer in Bangladesh, the monitoring role of IFDC has been a profound factor in the success of liberalization.

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Appendix

Table A1
Selected time series data on production, input use, and prices

Year	Production of rice (1000 tons)	Rice price (TK ton^{-1})	Fertilizer consumption (1000 tons)	Irrigated area (1000 acres)	Retail fertilizer (TK ton^{-1})	Diesel price (TK ton^{-1})	Short term crop loan (million TK)
1975/1976	12763	3382	451	1297	1361	2075	625
1976/1977	11752	3023	509	1350	1633	2107	687
1977/1978	12970	3877	725	1432	1633	2164	1085
1978/1979	12849	4216	698	1464	1905	2164	967
1979/1980	12740	5657	797	1542	2450	2776	1354
1980/1981	13882	4770	820	1676	2994	5043	1976
1981/1982	13631	6060	772	1764	3605	5499	2186
1982/1983	14215	6700	885	1889	3943	7574	3511
1983/1984	14508	7450	1032	1920	4007	7575	5110
1984/1985	14622	8250	1247	2073	4749	7574	5194
1985/1986	15041	6620	1152	2098	4995	7643	3902
1986/1987	15456	9160	1317	2199	4931	8828	3125
1987/1988	15661	9970	1505	2743	4924	8192	3831
1988/1989	15794	9810	1645	3154	4639	8245	3300
1989/1990	17462	9600	1968	3785	4648	8564	2573
1990/1991	17852	10650	1984	4732	4725	8572	2482
1991/1992	18252	9720	2124	6009	5004	8715	2492
1992/1993	18495	9637	2234	7391	5390	8802	2397

Sources: Bangladesh Bureau of Statistics (1991, Khalil (1989). Diesel price data and data for 1992/1993 were collected by personal contact with the Bureau of Statistics and the Ministry of Energy, Government of Bangladesh.

Table A2
Annual rate of change (%) in variables of the model

Variable	Period 1 1975–1984	Period 2 1985–1992
Rice production (QR)	2.09	3.19
Rice area irrigated (AG)	5.42	20.49
Dryland rice area (DAR)	0.12	−3.85
Rice price (nominal) (PR)	11.52	3.76
General price index (P)	10.43	6.97
Fertilizer price (retail) (PFR)	15.69	0.58
Fertilizer price (factory-gate) (PFD)	14.69	4.42
Fertilizer price (world) (PFM)	4.67	0.23
Fertilizer consumption (FC)	9.0	10.04
Diesel price (PD)	20.14	1.31
Short-term credit	28.83	−7.0
Long-term credit	52.67	19.98
Public expenditure on water control (EG)	16.57	9.12